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Effects of Cues and Prompts Instructional Scaffolding on Secondary School Students' Retention of Chemistry Concepts

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Abstract: *The study investigated the effect of cues and prompts instructional scaffolding on secondary school students' retention of chemistry concepts. Two research questions were raised to guide the study and three hypotheses which were tested at 0.05 level of significance. The study adopted pretest post-test non-equivalent control group quasi-experimental design. The population of the study was 2,530 SS2 chemistry students. The sample for the study was 120 SS2 students. Chemistry Achievement Test (CAT) validated by experts from the Department of Science Education and Education Foundation and one experienced chemistry teacher in Onitsha was used for data collection. The reliability of CAT was established using Kuder Richardson 20 (KR-20) which yielded reliability coefficient of 0.70. Data collected were used to answer the research questions using mean while hypotheses were tested at 0.05 level of significance using analysis of covariance (ANCOVA). The finding of the study showed that there was significant difference in the mean achievement scores of students taught chemistry using cues and prompts instructional scaffolding and those taught using conventional method in favour of cues and prompts instructional scaffolding. Gender was not a significant factor in the mean retention scores of students. The study recommended that chemistry teacher should integrate cues and prompts scaffolding into the teaching of perceived difficult topics in secondary school chemistry.*

Keywords: *Scaffolding, cues, task prompts, retention, titration*

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I. Introduction

Advancement in science and technology has become so dynamic that scientific knowledge is indispensable. The products of the numerous scientific advancement find applications in almost all the fields of life. It is pertinent that the masses should be able to use these products. To be able to use these products requires some level science literacy. Science literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity (Copriady, 2015).Not only is important to be science literate, it also necessary that developing countries like Nigeria should produce through her educational system scientists that can solve societal problems and boost her economy. Thus, there is need for mass science literacy and education in science for better life.

For life to be meaningful, the knowledge and practice of science must become preponderant to every child. However, the best way through which scientific literacy and skills can be made relevant to the child, is by incorporating scientific activities into school works and in the daily life of the child. Science knowledge should be such that the child sees it as being able tosolve his day to day needs, problems and challenges, rather than knowledge that is only relevant in the four walls of the classroom. One of the subjects studied at the secondary school level of education that could improve scientific knowledge is chemistry.

Chemistry studied the properties, uses and syntheses of matter. According to Opara and Waswa (2013) chemistry is everywhere; chemistry is life; and chemistry is the oracle of modern science. Chemistry education, therefore, enables the child to understand the world around him and should be taught from the on-set of science education. The aim of these objectives is to equip chemistry graduates with the necessary scientific literacy and skills that will enable them to face the changes and challenges of science in their society. However, Taber (2012) identified chemistry curriculum as commonly incorporating many abstract concepts, which are central to further learning in both chemistry and other sciences. Sirhan (2007) opined that these abstract concepts are important because further chemistry/science concepts or theories cannot be easily understood if these underpinning concepts are not sufficiently grasped by the student. This therefore, calls for the need to teach chemistry effectively, for better academic achievement by students.

Academic achievement is the outcome of learning, the extent to which the goals of instruction have been achieved by the students (Hattie, 2009). Achievement depicts how much students own learning. A lot of factors affect the achievement by chemistry students. These factors bear so much influence on the achievement of chemistry students that over the years, chemistry students do not show mastery of chemistry concepts. The situation is made worse by the fact that chemistry students have demonstrated in examinations that they engage more in rote learning than properly conceptualizing the chemistry concepts taught (Alabi, 2014). Their achievement have therefore, remained poor.

The commonest factor implicated for poor achievement in chemistry is the teaching method adopted by the chemistry teachers(Alabi ,2013). Poor teaching method results in rote learning which makes the studentsforget what they have learnt. To recall what is learnt, students must have to undergo meaningful learning. Retention has become a serious issue in learning chemistry and require that innovative teaching methods that could help students to improve retention be adopted by chemistry secondary school teachers. One of such innovative strategies is instructional scaffolding.

Instructional scaffolding has its origin from the work of Lev Vygotsky's socio-cultural theory and the concept of Zone of Proximal Development (ZPD). According to Vygosty, learning cannot take place in isolation of social interaction. What the learner can do within the social setting that involves More Knowledgeable Other (MKO) (adult, teacher or peer) he can represent individually. Scaffolding, according to Wood, Brunner and Rose (1976) is a process that enables the child or novice to solve a task or achieve a goal that would be beyond his unassisted effort. That is to say that scaffolding serves as a cognitive support that is used to bridge the gap between what the child knows and what he/she will be assisted to know. They stressed that Cognitive scaffolding is what a teacher does when working with a student "to solve a problem, carry out a task, or achieve a goal which would be beyond his unassisted efforts". The task at hand must be what the learner lack the ability to do at individual level, but can be guided through support provided by a person with more knowledge on the task at hand. One of the commonest instructional scaffolds used by teachers is cues and prompts.

According to Shane (2013), cues also called discriminative stimulus is the stimulus that tells the individual that it is time to engage in a certain behavior. It is a stimulus that ensures that students are on the right track towards solving a problem or understanding a concept. It dissociates cognitive distraction from students giving the right feedback over their learning. From this context cues tell the individual that reinforcement is available contingent on the behavior. The cue can be different depending on the support needs of the learner. For one person the cue for cleaning up after lunch could be the statement "lunch time is over" while for another person the cue could be the presence of dirty dishes. A statement that acts as a cue is called an instructional statement.Unlike a prompt, the cue will not fade away as part of a goal - it is a permanent part of the behavior. Ugwumba and Kodjo (2015) referred to cues as secondary stimulus which functions as guides to respond by way of perception or action to situation. Here cues are mainly targeted at helping the students recall previous learning which are necessary towards the present task or concept of learning. It can also be used to draw the attention of the students to specific attention of student on specific information they are about to experience during the learning process. If cues then are used to draw students' attention to anticipated situation, the cue can function as hints, which are necessary to make students alert and interested in new situations. In-essence cues are situation determined.

Cue should target at the specific response the teacher expects from the learners. Ugwumba and Kodjo (2015) further pointed out that when cues are used in the classroom they form a part of the tacit or unspoken knowledge of the learner and shift his/her attention to the required information source. Cues are essential teaching tools that enable the students to connect and integrate previous information to new learning. In this study cues are instructional strategies used by the teacher to facilitate proper understanding, retention and appropriate connection of concepts and skills which are effective in improving learning.

Prompts can be regarded as instructions, gestures, demonstrations, touches, or other forms of activities which the teacher undertakes while teaching which aimed at ensuring that the likelihood that learners will make correct responses is increased. A prompt is the artificial help that comes after the cue but before the response. The prompt is designed to help elicit the certain behaviour (Shane, 2013). Thus, through the use of cues and prompts the retention of chemistry concepts can be facilitated irrespective of students' gender. Since studies on gender influence of retention have remained inconclusive, the study investigated the place of gender on the students' retention.

Purpose Of The Study

The purpose of this study is to investigate the effect of cues and prompts instructional scaffolding on secondary school students' retention of chemistry concepts.Specifically, the study sought to find out the:

1. Effect of cues and prompts instructional scaffolding on the retention of students in chemistry when compared to that of those taught using conventional method.
2. Effect due to gender on the retention of male and female students in chemistry.

3. Interaction effect of teaching methods and gender on the retention of students in chemistry.

RESEARCH QUESTIONS

1. What is the mean retention scores of students in chemistry taught with cues and prompts instructional scaffolding and those taught with conventional method?
2. What are the mean retention scores of male and female students in chemistry?

HYPOTHESES

1. There is no significant difference in the mean retention scores of students in chemistry taught with cues and prompts instructional scaffolding and those taught with conventional method.
2. There is no significant difference between mean retention scores of male and female students in chemistry.
3. There is no significant interaction effect of teaching methods and gender on the retention of students in chemistry.

II. Method

Research Design

The study adopted quasi-experimental research design. It made use of the pretest post-test non-equivalent control group design. Dinardo (2008) referred to quasi-experiment design as an empirical study used to estimate the causal impact of an intervention on its target population without random assignment. Quasi-experimental designs typically allow the researcher to control the assignment to the treatment condition, but using some criterion other than random assignment. It is used where it is impossible to meet all the requirements of true experiment and when it is not possible to achieve randomization of subjects. There was no randomization since school administrators did not permit disorganization of their already organized classes, as a result intact classes were used. The design used is shown in Figure 1.

E	0_1	X	0_2
C	0_1	~X	0_2

Figure 1: Design of the Study

Where,
E = Experimental Group
C = Control group
0_1 =Posttest
0_2 = Retention
X = Cues and prompts instructional scaffolding
~X = Conventional method
--- = non-equivalence of the two groups

Area of the Study

The study was carried out in Ogidi Education Zone of Anambra state. This zone is one out of the six education Zones in Anambra State. The zone is made up of three local Governments Areas (LGAs) which include Oyi, Idemili North and Idemili South. The study involved all the government owned secondary schools in these three local governments. Ogidi Education Zone has large students' population; the students have the commitment to learn and struggle to contribute to the development of their society. Though school activities go on daily, these local governments are connected to commercial cities which to some extent may be a source of distraction to the academic pursuit of students. This has resulted into an extent of decrease in the commitment and achievement of students in this education zone. Therefore, the researcher deemed it fit to carry out this study in this area as it will be targeted at revamping the efficacy of students to academic success.

Population of the Study

The population of the study comprised all 2,530 SS2 chemistry students in all the public secondary schools in Ogidi Education Zone. There are a total of 40 publict owned secondary schools in Ogidi Education Zone with Oyi LGA having 11 schools, Idemili North sixteen 16 schools and Idemili south 13 schools (Post Primary Schools Services Commission, Ogidi Zone, 2016).

Sample and Sampling Techniques

The sample is made up of 120 senior secondary year two (SS2) chemistry students drawn from two secondary schools in the study area. Multistage sampling technique involving different technique at each stage was used. First, purposive sampling technique was used to select 26 co-educational schools from the 40 schools from Idemili North, Oyi and Idemili South. Coeducational schools were purposively selected to take care of the gender variable in the study. The schools were stratified into idemili North, Oyi, and Idemili south where they

are located. From the local governments, random sampling technique was used to select two local government areas. From the local government areas selected, one school from each was selected at random. In each school, all the SS2 chemistry students were used in the study.

Instrument for Data Collection

The instrument for data collection was Chemistry Achievement Test (CAT) developed by the researcher. The instrument is made up of section A and B. Section A contained the personal information of the participants such as name of school, sex, date of examination. The section B contained 25 items which were multiple choice items with option lettered A-D. The items were developed based on the concept that was taught during the study which is acid base titration. A table of specification was used to ensure that all the content areas taught were covered. The instrument was used as pretest, posttest and retention test (delayed posttest). Lesson plans were also developed for the experimental and control groups.

Validation of the Instrument

The Chemistry Achievement Test (CAT) was validated by one lecturer from the Department of Science Education, NnamdiAzikiwe University Awka, a chemistry lecturer from NwaforOrizu College of Education, Nsugbe, and an Educational Measurement and Evaluation experts from NnamdiAzikiwe University, Awka. The validators were given the CAT, the topic of the study, the purpose, research questions and hypotheses in order to enable them give the appropriate guidance. They were asked to validate the instrument with regard to the clarity of the test language, relevance to the topics selected for the study. The content validity of the instrument was done using the table of specification developed for CAT. This was to ensure that the instrument is fit for the collection of data and also relevant to the content of the study. Their corrections and contributions were duly effected which gave rise to the final instrument used for data collection.

Reliability of the Instrument

In order to ensure that the CAT is reliable, the instrument was administered to 20 students chosen from community secondary school Ozubulu in Ekwusigo L.G.A who are not part of the study. The internal consistency of the instrument was established using Kudar Richardson 20 (KR-20) and has the reliability coefficient of 0.70. KR_{20} was used because the items of the CAT do not have the same level of difficult, and each of the questions is dichotomously scored.

Experimental Procedure

The regular school teacher of the experimental group was used to teach the students in the experimental and same also with the control group. The difference was that the teachers in the experimental group were briefed on how to use the lesson plan prepared using cues and prompts instructional strategies, they were also brief on what cues and prompts are to ensure they were familiar with it before using it to teach. The teachers in the control group were asked to teach with their usual teaching technique.

The study lasted for eight (8) weeks. The treatment (teaching) was done according to the regular school timetable by the research assistants who were the regular school teachers of the schools used. The timetable allocated one double period (80 minutes) and one single period (40 minutes) for chemistry every week. These periods were used to teach the students for four weeks, where each topic lasted for one week.

The chemistry achievement test (CAT) was administered to the students in the first week of the six weeks as pretest. This is to ascertain the previous knowledge the students have, on the concept they were exposed to during the study. This took effect in both the control and experimental group. The pretest marks the beginning of the treatment in both groups, thereafter school teachers took off with the treatment which lasted for 4 weeks. The 6^{th} week in study was used for posttest for chemistry achievement. During these periods there was regular monitoring by the researcher on the research assistants. However two weeks after the post-test the CAT was re-administered to the students as retention test.

Control of Extraneous Variables

The following measures were taken to control extraneous variables likely to adversely affect the conduct of the experiments and the results obtained thereof:

Pretest Interference**:** To ensure that there was no interference of pretest on the student during the posttest, the CAT used for pretest was reshuffled and reprinted using different paper color from that of pretest when used as posttest. This is to ensure that there is no pretest interference on the post-test.

Initial Group Difference:In order to ensure that the schools used are similar in characteristic and composition, Government schools and co-educational schools were used for both the experimental group and control group. However, beyond school characteristics and composition, other initial group difference and

limitations inherent in experimental and control groups were adjusted by using Analysis of Covariance (ANCOVA) in data analysis.

Hawthorne Effect:Hawthorne effect is as a result of students faking their behaviour when they perceive that they are being used in an experiment and this may affect the outcome of the study. The regular school chemistry teachers were therefore used in the study.

Class Interaction**:** To ensure that the experimental subjects did not interact, the school used in the study were miles apart.

Experimenter Bias:The regular chemistry teachers were trained by the researcher and used to teach the students. This helped to curtail the effect of experimenter bias.

Method of Data Collection

Chemistry Achievement Test (CAT) was administered as pretest to the both experimental and control groups before treatment. Posttest was administered after the four weeks of teaching of chemistry concepts. Three weeks after the post-test, the retention test was administered to the students. The CAT contained 25 items. Four (4) marks were allotted to each item correctly answered to make a total of 100 marks which was the highest mark to be scored. The Chemistry Achievement Test (CAT) was administered to the experimental and control groups by the school teachers who are also the research assistants under the guidance of the researcher.

Method of Data Analysis

The research questions were answered using mean while hypotheses were tested at 0.05 level of significance using analysis of covariance (ANCOVA). ANCOVA was used to take care of the initial group difference that existed due to due to non-randomization of the students.Decision rule: Where Pvalue was less than 0.05, the null hypothesis was rejected but where it was greater than 0.05 the null hypothesis was not rejected.

III. Results

Research question 1: What is the mean retention scores of students in chemistry taught with cues and prompts instructional scaffolding and those taught with conventional method?

Table 1: Mean Achievement Scores of Students taught Chemistry with Cues and Prompts Scaffolding and those taught with Conventional Method

Group	N	N	Posttest mean	Retention mean	Lost Mean	Posttest SD
Experimental	57	57	62.60	62.42	-0.18	18.17
Control	63	63	43.13	40.35	-2.78	16.43

Table 1 shows that students taught with cues and prompts instructional scaffolding had retention mean score of 62.42 which varied by 22.07 from the students taught with expository method who had mean retention score of 40.35. This showed that cues and prompts group retained chemistry concept taught better than expository group. In the experimental group, the variation of retention scores (18.63) was higher than the variation of scores in the control group (16.00).

Research question 2: What are the mean retention scores of male and female students in chemistry?

Table 2: Mean Retention Scores of Male and Female Students taught Chemistry

Group	Gender	N	Posttest mean	Retention mean	Lost Mean	Posttest SD	Retention SD
Exp.	Male	27	65.93	65.63	-0.30	15.16	15.34
	Female	30	59.60	59.53	-0.07	20.00	21.00
Control	Male	32	42.09	39.38	-2.71	16.99	16.73
	Female	31	44.19	41.35	-2.84	15.84	15.42

Table 2 shows that the mean retentionscore of male students exposed to cues and prompts instructional scaffolding was 65.63 while the female students under the same instructional pattern had retention mean score of 59.53. Male students loss in mean of -0.30 and female students had loss in mean of -0.07. Also, while cue and prompt instructional scaffolding increased the spread of scores for female students more than it did among the male students. The retention mean score of male students exposed to expository instruction was 39.38 while the female students under the same instructional pattern had retention mean score of 41.35. Male students' loss in mean of -2.71 and female students' loss in mean of -2.8.

Hypotheses 1: There is no significant difference in the mean retention scores of students in chemistry taught with cues and prompts instructional scaffolding and those taught with expository method.

Table 3: ANCOVA on Effects of Cues and Prompt Instructional Scaffolding and Conventional Methods on Retention in Chemistry

Source of variation	SS	Df	MS	F	P-value
Corrected Model	48223.841[a]	4	12055.960	834.787	.000
Intercept	2.130	1	2.130	.147	.702
Pretest	33055.534	1	33055.534	2288.853	.000
Gender	.005	1	.005	.000	.985
Method	199.313	1	199.313	13.801	.000
Gender * Method	.248	1	.248	.017	.896
Error	1660.826	115	14.442		
Total	359968.000	120			
Corrected Total	49884.667	119			

Table 3 shows that there was a significant main effect of the treatment on the retention of students in chemistry F (1, 119) = 13.801, P<0.05. Therefore, null hypothesis was rejected. Thus, there is significant difference in the mean retention scores of students in chemistry taught with cues and prompts instructional scaffolding and those taught with expository method.

Hypotheses 2: There is no significant difference between the mean retention scores of male and female students in chemistry.

Table 3 also shows that there was no significant main influence of gender on the achievement of students in chemistry F (1, 119) = .000, P>0.05. Therefore, null hypothesis was not rejected. Thus, there is no significant difference in the retention of male and female students in chemistry.

Hypotheses 3: There is no significant interaction effect of teaching methods and gender on the achievement of students in chemistry.

Table 3 further shows that there was no significant interaction of teaching method and gender on retention of students in chemistry F (4, 119) = 017, P>0.05. Therefore, null hypothesis was not rejected. Thus, there is no significant interaction effect of teaching methods and gender on students' retention in chemistry.

IV. Discussion, Conclusion And Recommendations

In term of retention of chemistry concepts, the findings of the study revealed that students taught with cues and prompts instructional scaffolding were significantly better in retention than their counterparts taught with expository. Cues and prompts help to build encoding and retrieval codes which enabled the students to properly retain what they were taught. It also helped build their understanding on chemistry concepts and their retention was enhanced. Akinsola and Odeyemi (2014)found out thatthrough the use of mnemonic strategy, it is more likely that the students will be able to remember factual information, answer questions, and demonstrate comprehension. Mnemonic is a form of cue, and enabled students to remember knowledge they are exposed to. Therefore cues and prompts built a strong retrieval cue that enabled the student to appropriately recall what they were taught overtime. It enabled the students to appropriately transfer the learned knowledge from the short term memory to the long term memory which enhanced their remembering ability and reduced rote memorization. Cues and prompt engaged the students in such a way that they made conscious effort to learn. They therefore became accountable for their own learning. These efforts and engagement in the learning process enhanced retention. This finding of the study is line with that of Efe (2015) who reported that there was significant difference in students' performance when discussion and lecture strategies were used to teach chemistry in favour of discussion. Discussion or conversation could use as a form of cue to lead students to foundational knowledge about a concept from where they may learn more about the concept without the teacher.

From the findings of this study it was obvious that male and female students exposed to cues and prompts instructional strategy did not significantly differ in their retention. It is paramount to say that cues and prompts instructional scaffolding is not among the teaching methods that is gender bias. Once the principles of its application are properly followed both male and female students will benefit equally. Male and female students were able to retain what they were taught. This is as a result of the fact that cues and prompts set a good background, which enabled them to easily remember what they were taught overtime gender notwithstanding. This finding is in line with the work of omiko (2015) who found out that there isno significant effect of scaffolding method used on gender, as both performed well. Also Nbina and Avwiri (2014) and Muhammad (2014) in their separate studies, reported that gender has no effect on students achievement.

This study has proved that cues and prompts significantly improved secondary school students' achievement in chemistry without gender bias. Therefore, with cues and prompts instructional scaffolding, chemistry teachers can create a better learning environment where the students can interact with the learning materials and among their peers with the aid of the teacher to discover and reach solutions to their academic needs. With chemistry being regarded as abstract subject, the application of cues and prompts could make it

easier for students to understand and apply their own ingenuity to effectively learn the subject. Also, the strategy could be used to equip students with skills that will enable them not only to succeed in classroom learning but also skills that could enhance their memory ability. With this enhanced memory ability; rote memorization could be avoided, and groom the students to become life-long independent learners. From the findings of the study and the implications of the findings, the following recommendations were made:

1. Chemistry teacher should integrate cues and prompts scaffolding into the teaching of perceived difficult topics in secondary school chemistry. This will go a long way in diffusing the abstractness of most chemical concepts.
2. School authorities should make adequate provision of time and resources which will enable chemistry teachers to effectively use innovative strategies and methods such as cues and prompts instructional scaffolding.
3. The government should encourage and sponsor teachers of chemistry for in-service training, conferences and seminars that will give them opportunity to learn and get acquainted with innovative teaching methods such as instructional scaffolding.

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